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Apparatus of the Pennsylvanian Conodont Genus *Neognathodus*

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Abstract

The discovery, in existing collections, of three natural conodont assemblages of one or more species of *Neognathodus* illuminates the element composition of species of this genus and permits comparison with the element compositions of apparatuses of species of related genera belonging to the Family Idiognathodontidae.

The apparatuses of the one or more species of *Neognathodus* that were studied are Type 1 apparatuses and contain Sp, Oz, Ne, Hi, and probably Tr elements. The Sp (platform) element is neognathodiform. The Sp, Oz, and Ne elements were probably present as single pairs, whereas the Hi elements were probably present in as many as four pairs, with possible substitution of an unpaired Tr element for one of these Hi element pairs. This apparatus composition is probably representative for use as an element blueprint for species of the genus *Neognathodus*.

The described overall element composition is practically identical with that of apparatuses of species of *Streptognathodus* and *Idiognathodus*. The gross morphology of the Sp elements of these species of *Neognathodus* easily distinguishes them from species of related genera. Differences in the Oz and Hi elements, although more subtle, can possibly be used in a like manner to differentiate this genus. The Ne and possible Tr elements could not be characterized because of their paucity.

Despite possible claims of priority for Jones's name *Bicarinodus* or for *Illinella* Rhodes, *Neognathodus* Dunn remains the correct name of the genus.

Introduction

Nearly all genera of Late Carboniferous conodonts are now known to have possessed multielemental apparatuses (Table 1). One of the most significant exceptions has been the Lower and Middle Pennsylvanian genus *Neognathodus*. Merrill (1975: 67) unsuccessfully attempted to reconstruct this apparatus with disjunct collections from an unusual and restricted *Neognathodus*-biofacies. The discovery in existing collections of three natural assemblages of one or more species of *Neognathodus* illuminates the element composition of this genus and permits comparison with the apparatuses of similar genera.

Table 1. Sources of information about Late Carboniferous multielemental conodont genera.

Genus based on disjunct elements	Junior synonyms based on natural assemblages	Principal studies based on	
		Assemblage material	Disjunct elements
Idiognathodus *Streptognathodus*	*Scottognathus*	Du Bois, 1943; Rhodes, 1952; Avcin & Norby, 1972, 1973	von Bitter, 1972; Baesemann, 1973
Cavusgnathus	*Lewistownella*	Scott, 1942	von Bitter, 1972; Baesemann, 1973
Anchignathodus[1]	—	—	von Bitter, 1972;[2] Baesemann, 1973[3]
Gondolella	*Illinella*	Rhodes, 1952; von Bitter, 1976	von Bitter, 1972, 1974, 1976; Merrill, 1975
Stepanovites	—	—	von Bitter, 1972;[4] Kozur, 1975
Idioprioniodus	*Duboisella*	Rhodes, 1952	von Bitter, 1972;[5] Baesemann, 1973; Merrill & Merrill, 1974
Aethotaxis	—	—	Baesemann, 1973

[1]Suggested by Sweet (1976) that *Hindeodus* may be a senior synonym.

[2]Reconstructed as two apparatuses, *Anchignathodus* and *Ellisonia*, by von Bitter (1972).

[3]Referred to *Ozarkodina* by Baesemann (1973).

[4]Referred to *Delotaxis?* by von Bitter (1972).

[5]Referred to *Neoprioniodus* by von Bitter (1972).

Materials and Methods

The three natural assemblage specimens studied come from the collections of the Field Museum, the University of Illinois, and the University of Missouri. Disjunct conodonts from Merrill (1975) were used for comparative purposes.

The natural assemblage from the Field Museum was coated with gold and was examined and photographed with the Cambridge Scanning Electron Microscope at the Royal Ontario Museum. The natural assemblage from the University of Missouri was initially coated with silicon monoxide and carbon and was studied and photographed with the Scanning Electron Microscope at the University of South Carolina. Subsequently, the specimen was coated with gold and photographed using the SEM facilities at the Royal Ontario Museum. The specimen from the University of Illinois was examined by standard binocular microscopy. Photographs taken through this medium were provided by Dr. R. Norby of the Illinois State Geological Survey.

Systematic Palaeontology

Order Conodontophorida Eichenberg, 1930
Superfamily Polygnathacea Bassler, 1925 emend. Lindström 1970
Family Idiognathodontidae Harris and Hollingsworth, 1933 emend. Lindström 1970

Genus *Neognathodus* Dunn, 1970

Diagnosis
Type 1 apparatuses of Klapper and Philip (1971) containing Sp, Oz, Ne, Hi, and probably Tr conodont elements. The Sp element is neognathodiform. Angulodontiform elements may be present but were not recognized.

Type Species
Polygnathus bassleri Harris and Hollingsworth, 1933, by original designation.

NATURAL ASSEMBLAGE 1

Neognathodus cf. *dilatus*
Fig. 1

Description
Rhodes (1952) erected the monotypic multielement conodont genus *Illinella* (senior synonym = *Gondolella* Stauffer and Plummer, 1932) with the type species *I. typica*. The holotype of this species was based on certain conodont elements present on a

bedding plane of black shale bearing the University of Illinois catalogue number X-1505.

In addition to the elements belonging to a species of *Gondolella* described by von Bitter (1976), the shale chip referred to above contains two neognathodiform Sp elements (first pointed out to us by R. Norby, pers. comm., 1974), one (probably two) Hi elements, an Oz element, and the probable posterior process of a Tr element, all interpreted to belong to *Neognathodus* cf. *dilatus* (Fig. 1). This interpretation results from exclusion of these Hi, Oz, and Tr elements from the *Gondolella* apparatus, as reconstructed by von Bitter (1974, 1976) as well as the identification of the two closely associated Sp elements as neognathodiform. This identification is based on the presence of a characteristic arched carina bearing rounded, nearly equidimensional nodes, as well as the stratigraphic level of the specimen. The inner row of nodes, characteristic of neognathodiform elements, is lost in the element preserved as a partial mould and is embedded in matrix in the case of the complete Sp element. The Hi elements, although lacking anterior or posterior termini, are clearly hindeodelliform and possess the alternating denticles of Hi elements that are found in similar genera such as *Streptognathodus* and *Cavusgnathus* (von Bitter, 1972). The probable Tr element, although only showing as the posterior bar (either because of breakage or burial), similarly has hindeodellid denticulation. The single Oz element present is incomplete but is similar in general morphology to Oz elements found in the apparatuses of species of *Streptognathodus* and *Idiognathodus* (von Bitter, 1972).

Taxonomic Assignment

This material comes from a lower Desmoinesian black shale in Adams County, Illinois, that has been called "Mecca Quarry Shale" by the Illinois Geological Survey (Collinson et al., 1972, fig.17) on the assumption that it is a correlative of the Mecca Quarry Shale of Indiana. The stratigraphic position of the Illinois black shale is at or near the base of the Oak Grove Member in western Illinois, and no distinction is made between them by some authors (Merrill and King, 1971; Merrill, 1975). The occurrence of *Neognathodus dilatus* in Oak Grove beds is well documented in these two studies and would in no way be inconsistent with this identification, although the bulk of the neognathodiform fauna in the Oak Grove Member is less advanced phylogenetically. Similarly, gondolelliform conodonts from this locality are examples of "primitive" *Gondolella bella* (Merrill, 1975), and strongly support an age assignment close to that of the type Oak Grove Member of northwestern Illinois.

Material

1 specimen, University of Illinois, X-1505.

NATURAL ASSEMBLAGE 2

Neognathodus* cf. *dilatus
Figs. 2; 3; 4; 5; 9A, C

This specimen is assemblage 12 of Burnley, MS 1938.

Description

This natural assemblage exhibits a moderate amount of dispersal of the elements like that described by Collinson, et al. (1972, especially fig. 10F) as ''contraction and rotation''. It contains a pair of neognathodiform Sp elements, a pair of well-preserved Oz elements, and five or more Hi elements (Figs. 2, 3, 4, 5). No Ne elements are present, nor were Tr elements observed, although poorly preserved unidentifiable conodont fragments present in the specimen may represent such elements. The count of at least five Hi elements is based on the presence of five rather long, relatively unbroken hindeodelliform bars. There are three anterior and two possible posterior termini of Hi elements present.

The two neognathodiform conodont elements are identified as the Sp elements of *Neognathodus* cf. *dilatus* by the presence of at least two rows of diverging, rounded equidimensional nodes on the oral surface (Fig. 4A, B). The two Oz elements are well preserved (Fig. 5A, B) and members of the pair expose opposite anterior and posterior processes. The degree of arch between processes is relatively low and the largely discrete denticles are reclined only a few degrees beyond being set perpendicular to the process. There is a relatively slight difference in size between the apical denticle (or cusp) and the adjacent denticles on either process. These denticles gradually decrease in size away from the apex, but remain relatively large to the extremes of the unit. Two of the anterior termini of the Hi elements are preserved as moulds, but all three have similar morphologies (Figs. 3; 5C , D). The preserved anterior portions of these bars are distinct from those of the Hi elements of related genera such as *Streptognathodus* and *Idiognathodus* (von Bitter, 1972), in that anterior to the cusp they possess a process that is gently curved laterally and angled slightly downward. The major aboral deflection is near the extreme anterior tip of the process, producing a rounded terminus with recurved projections above and below. Additionally, the denticle spacing on this anterior process is relatively wide in comparison with similar elements in other genera.

Taxonomic Assignment

Platform elements in this natural assemblage suggest a specific assignment at least as phylogenetically advanced as *Neognathodus dilatus*. This identification is supported by the upper Desmoinesian source of the specimen. Burnley (MS 1938) collected this specimen from the ''Lexington Coal Zone'', now the Anna Member, in a deep mine near Kansas City, Missouri. This specimen has been considered to come from the same stratigraphic interval as Gunnell's (1931) collection that includes the holotype of *Neognathodus roundyi*. Topotypes from Gunnell's locality demonstrate that most of the neognathodids there are more phylogenetically advanced than the one he described as *N. roundyi*. Thus a specific assignment for Burnley's specimen to *N. dilatus* is completely compatible with our knowledge of the neognathodid fauna of this stratigraphic interval.

Material

1 specimen, University of Missouri, UMC 1078-7 [catalogue number C-B10-23 of Burnley, MS 1938].

Neognathodus sp.
Figs. 6; 7; 8

This specimen is assemblage 4 of Jones (MS 1938).

Description

This is the best preserved of the three natural assemblages studied. It contains a pair of neognathodiform Sp elements, two well-preserved Oz elements, a single Ne element, and five or more Hi elements (Figs. 6; 7; 8). The count of at least five Hi elements is based on the presence of five posterior termini. It is possible that one or more of these posterior tips is the posterior process of one or more Tr elements. Only a single Hi element shows a well-preserved anterior terminus.

Both Sp elements are well preserved in this natural assemblage even though one of them (Fig. 7D) is broken away on the exposed (inner?) side of the median carina. Nodes on the carinae of the Sp elements (Figs. 7D; 8B) are more pointed than the average, but are otherwise similar to the Sp elements in natural assemblages 1 and 2. The complete Sp element in natural assemblage 3 (Fig. 7A, B, C) preserves a flanking (inner?) nodose row that consists of low rounded nodes. These nodes together form the characteristic overhanging parapet (Fig. 7A, B, C) found in the neognathodiform Sp elements of species of *Neognathodus*. The Oz elements (Figs. 6; 7A) are, in their embedded state, nearly impossible to distinguish from those belonging to species of *Streptognathodus* and *Idiognathodus* (von Bitter, 1972). They do, however, exhibit relatively fewer larger denticles than are common in the Oz elements in species of those genera, and are nearly erect and discrete. The Hi elements show the alternating hindeodellid denticulation typical of the Hi elements of species belonging to the Idiognathodontidae. A single specimen (Fig. 6) shows a gently curved anterior end that is more similar to the corresponding element in species of *Cavusgnathus* than it is to the Hi elements of species of *Streptognathodus* or *Idiognathodus* (von Bitter, 1972). This is based upon the observation that the anterior process of the Hi elements of species of *Cavusgnathus* is deflected more laterally than and not as aborally as in the species of the latter genera (von Bitter, 1972). The pattern of denticulation of this specimen indicates widely spaced, mostly small denticles on the process anterior of the cusp. One Hi fragment in the top right corner of Fig. 6 shows a sharp flexure reminiscent of *Hindeodella parva* Ellison. The single Ne element (Fig. 8C, D) is partially buried. The cusp is exposed, however, and establishes that this part was a relatively massive structure with a moderate lateral and aboral expansion. Two unidentified fragments, one relatively near this Ne cusp, and one sandwiched between the Oz elements, have denticulation similar to that of some disjunct Ne elements of species of *Idiognathodus* and *Streptognathodus*.

Taxonomic and Age Assignment

Although this is by far the best preserved of the three natural assemblages available to us, the partially buried and broken nature of the platform (Sp) elements makes it impossible to view these elements more closely. Thus we cannot with confidence assign this specimen to a particular species. It could belong to *Neognathodus dilatus*, but it is is also possible that it, and disjunct specimens referred by Jones (MS 1938) to

Bicarinodus typicus, are conspecific with more advanced species such as *N. metanodosus* or *N. polynodosus.*

A minor problem involves the age of Jones's material. His three localities are all listed as belonging to the Seminole Formation, which standard correlation charts (Moore et al., 1944) generally show as being oldest Missourian. No neognathodids are known from rocks younger than Desmoinesian in the eastern half of North America and it is improbable that these represent an exception. It seems more likely either that the rocks from which Jones (MS 1938) collected this specimen were incorrectly identified, i.e., miscorrelated, or that the rocks at this locality are older than generally believed.

Material

1 specimen, Field Museum, W.M. 44604.

Minimum Numbers and Kinds of Elements in the Apparatus of Species of Neognathodus

Each of the three extant assemblage specimens of species of *Neognathodus* shows two neognathodiform Sp elements. These are assumed to be paired dextral and sinistral elements as in species of closely related genera *(Streptognathodus, Idiognathodus).* Although Avcin and Norby (1972) reported natural assemblage specimens of species of *Streptognathodus* or *Idiognathodus* bearing more than a single pair of Sp elements, the vast majority of platform-bearing apparatuses known from natural assemblage material contain a single symmetric pair, as do the apparatuses of species of *Neognathodus* examined by us. Two of the three specimens show two Oz elements. These probably formed symmetrical pairs for the reason cited above. The single unquestioned Ne element is not a sufficient basis on which to formulate a conclusion. Nevertheless, this kind of element is present and, like similar elements in species of *Streptognathodus* and *Idiognathodus* (von Bitter, 1972), was probably symmetrically paired. Burnley (MS 1938) and Jones (MS 1938) described seven and four Hi elements in natural assemblages 2 and 3, respectively. Although we chose to use what may be more conservative enumeration techniques and recognize only five Hi elements in each, Burnley's figure may not be excessive. In the *Idiognathodus–Streptognathodus* plexus, the most common number of Hi elements appears to be four pairs, or eight (Rhodes, 1952). We consider it likely that species of *Neognathodus* bore an equivalent number.

Avcin and Norby (1973) and Baesemann (1973) suggested that members of the *Idiognathodus–Streptognathodus* plexus might have possessed more than one kind of Hi element. We were unable to recognize this in the natural assemblage specimens of *Neognathodus* available to us. Von Bitter (1972) and Avcin and Norby (1973) suggested the presence of a bilaterally symmetrical Tr element either in addition to the eight Hi elements, or possibly substituting for one pair of them. Our discovery of the posterior bar of a probable Tr element in natural assemblage 1 is not inconsistent with this suggestion.

Table 2 summarizes the conodont elements in the three natural assemblages studied. Although we cannot be completely confident of the element ratios in the apparatus of species of *Neognathodus,* the minimum element composition shown in Table 3 seems reasonably well supported.

Table 2. Summary of numbers of conodont elements visible in the apparatuses of one or more species of *Neognathodus*.

	Assemblage 1 — University of Illinois, X-1505, *N.* cf. *dilatus*	Assemblage 2 — University of Missouri, UMC1078-7, *N.* cf *dilatus*	Assemblage 3 — Field Museum, W.M. 44604, *Neognathodus* sp.
Sp	2	2	2
Oz	1	2	2
Ne	—	—	1
Hi	1+	5	5[1]
Tr	?1	—	—

[1]Based on posterior tips present, one or more of which may represent the posterior bar of a Tr element.

Table 3. Minimum element composition of species of *Neognathodus* based on natural assemblages 1, 2, and 3. Uncertain or possible substitutes in parentheses. Arrangement relatively arbitrary but conforms to configurations shown by Rhodes (1952) and Collinson, et al. (1972).

Sp	Sp
Oz	Oz
Ne	Ne
Hi	Hi
Hi	Hi
Hi	Hi
(Hi)	(Hi)
(Tr)	

Morphology of Conodont Elements of Species of Neognathodus *Compared with those of Similar Species*

The Sp or platform elements of species of *Neognathodus* are distinctive enough to have warranted separation from other gnathodiform platform genera (Dunn, 1970). Although this separation is relatively easy, the question remains whether or not the non-platform elements of species of *Neognathodus* are morphologically distinct from those of contemporaneous species of *Idiognathodus* or *Cavusgnathus*.

The non-platform elements in these three specimens were compared with similar

disjunct elements from contemporaneous apparatuses of *Idiognathodus* (Fig. 9). There are strong morphologic similarities between comparable elements of the two genera, but minor differences exist. The Oz elements of the species of *Neognathodus* examined (Fig. 9A) differ from those of *Idiognathodus* (Fig. 9B) primarily in that their denticles are fewer in number, more discrete and more triangular in outline, relatively large in comparison with the cusp, and generally more erect relative to the process to which they are attached. The Oz elements of species of *Idiognathodus* (Fig. 9B) have denticles that are more numerous, more crowded to the point of overgrowing part of their number in larger, presumably more mature specimens, more elongate, smaller in comparison with the cusp, and generally more strongly reclined. Furthermore, Oz elements from the apparatuses of species of *Idiognathodus* tend toward strong downward deflections at their anterior and posterior termini (Fig. 9B), a characteristic not observed in the apparatuses of species of *Neognathodus* examined (Fig. 9A).

Posterior termini and the long bar-like segments behind the cusps of the Hi elements of species of the two genera cannot at present be differentiated. The anterior processes differ in that those of species of *Neognathodus* (Fig. 9C) have a more lateral, rather than aboral, overall deflection, a wider denticle spacing, and a terminal aboral projection that is farther from the cusp than in comparable elements of species of *Idiognathodus*. By possessing an initially lateral, rather than aboral, deflection, these elements most closely resemble Oz elements of species of *Cavusgnathus* (von Bitter, 1972).

Definitive morphologic characters are difficult to define on the basis of the one Ne element present in natural assemblage 3. If the unidentified fragment sandwiched between the Oz elements of natural assemblage 3 (Fig. 7A) represents an Ne element, then this element too is characterized by wide denticle spacing. The Ne element in natural assemblage 3 (Fig. 8C) bears two lateral bars on which strong, individually placed (i.e., non-hindeodellid) denticles are present. The posterior bar (on the right side of Fig. 8C) is stouter and bears heavier denticles than does the anterior bar. Both the cusp and the bar denticles are decorated (Fig. 8D) with discontinuous striae, are slightly compressed, and possess a keel on each lateral edge. Although damaged, a moderately large flaring apron is present on the Ne element. In all of these characters it most closely resembles the Ne element of species of *Gondolella* (von Bitter, 1976).

The probable Tr element in natural assemblage 1 differs from the comparable Tr element in species of *Idiognathodus* in having somewhat more arch in the posterior process (the only part preserved); we suggest that this process might have been shorter originally, and less distinctly "hindeodellid", i.e., alternating sized denticulation. In general form, however, the part preserved is quite similar to Tr elements found in species of *Idiognathodus*.

The Issue of Nomenclature

Jones (MS 1938) described natural assemblage 3 (= Field Museum, W. M. 44604) as follows [our comments in parentheses]:

"This may be regarded as a typical assemblage of the *Bicarinodus* type. It consists of two excellent pairs of *Hamulosodina* [= Hi elements], one pair lying across the

other pair, but with the denticles of one pair pointing toward the other, and all denticles sloping in the same direction–posteriorly. Two excellent specimens of the form *Bicarinodus typicus* [= Sp or platform elements] lie adjacent to each other, but with their anterior ends pointing in opposite directions. As in the previously described assemblages, two specimens of *Bryantodus* [= Oz elements] lie adjacent to the *Bicarinodus,* with their inner sides toward each other, and with their denticles sloping in opposite directions.''

Had Jones's dissertation been published, then *Bicarinodus* Jones would have precedence over the later named *Neognathodus* Dunn. Although Jones distributed lithoprinted copies of this dissertation (1941) we agree with Fay (1952: 33) that this did not constitute publication in the sense of the International Code of Zoological Nomenclature. Our agreement with Fay, however, rests not on the lack of copyright, but rather on the fact that Jones distributed only a few copies to libraries and other institutions and that the document was never available for general sale or free distribution (International Commission on Zoological Nomenclature, Article 8(3), 1964). This distinction is important, for otherwise Jones's name *Bicarinodus* would be an available senior synonym of *Neognathodus* instead of, as we believe, a *nomen nudum*.

Rhodes (1952) described the monotypic genus *Illinella* on the basis of natural assemblage specimens. It was pointed out by von Bitter (1976) and has been shown in this paper that the holotype of *I. typica* contains the elements belonging to species of two genera, *Gondolella* and *Neognathodus*. It has now been accepted (von Bitter, 1972, 1976; Sweet, *in* Ziegler, 1973) that *Illinella* is a junior synonym of *Gondolella* Stauffer and Plummer, 1932. The question that remains is whether or not the name *Illinella* has any claim of priority over *Neognathodus*.

In spite of the vagueness in the zoological concept of the nature of the specimen, there does not appear to us to be a real case for the name *Illinella* to be applied to what we refer to as *Neognathodus*. Recognition that the author's ''type specimen'' consisted of parts of two or more individuals by the usual application of the word in no way makes mandatory the retention of the original name for parts other than those included in the original description/definition. Platforms (and other elements) of *Neognathodus* fit into neither Rhodes's diagnosis and definition of *Illinella* nor the revision of *Gondolella* (von Bitter, 1976). Rhodes (1952) misinterpreted some of the elements and identified the two Sp elements belonging to *Neognathodus* as the ''*Lonchodus* component'' of *Illinella,* although these two elements have finer denticles than other elements identified by Rhodes as *Lonchodus*. *Illinella* was defined as containing platform elements assignable to *Gondolella* as well as elements called *Lonchodus* and *Lonchodina*. The names *Lonchodus* and *Lonchodina* cannot be applied correctly to these elements in any formal sense (von Bitter, 1976) and only taxa with gondolelliform elements could be included in Rhodes's genus. Intruder elements, even when they constitute the bulk of the ''specimen'', are excluded.

Although the apparatus of the type species of *Neognathodus, N. bassleri,* has yet to be reconstructed, we think it probable that its element composition is directly comparable to that of the species of *Neognathodus* studied here. We therefore conclude that the generic name *Neognathodus* Dunn, 1970 is the proper name not only for the animals whose remains are preserved in the three natural assemblages, but also for now disassociated neognathodiform platforms that were associated with paired Hi, Oz, Ne, and other non-platform conodont elements during life.

Acknowledgments

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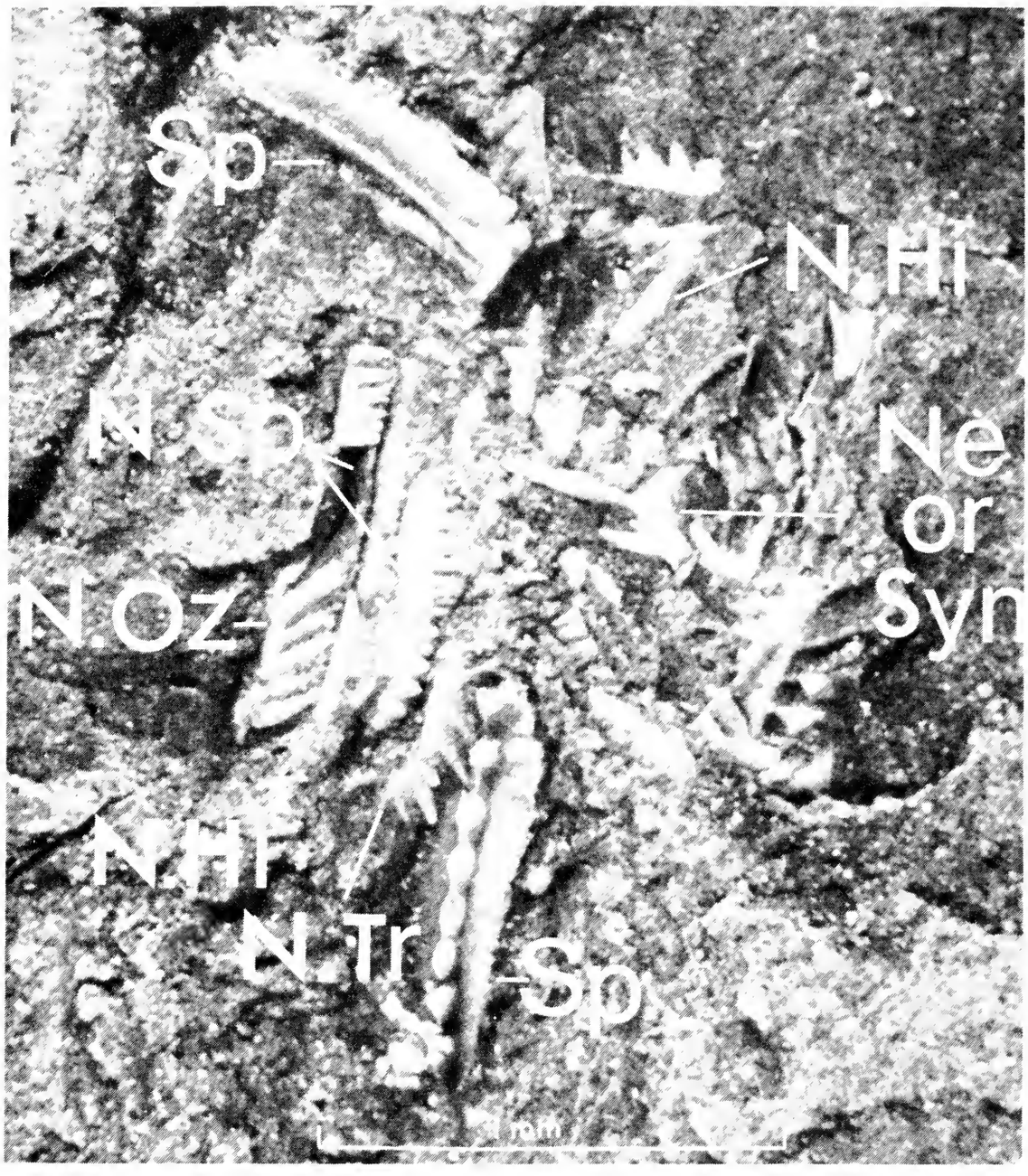


Fig. 1 *Neognathodus* cf. *dilatus* (Stauffer and Plummer) and *Gondolella* sp., natural assemblage 1, SE¼, SW¼, sec. 9 T1N R6W, Adams Co., Illinois, Mecca Quarry Shale (Middle Pennsylvanian). N. designates conodont elements interpreted to belong to the apparatus of *Neognathodus* cf. *dilatus*, University of Illinois, X-1505. [Modified from von Bitter, 1976, fig. 13A]

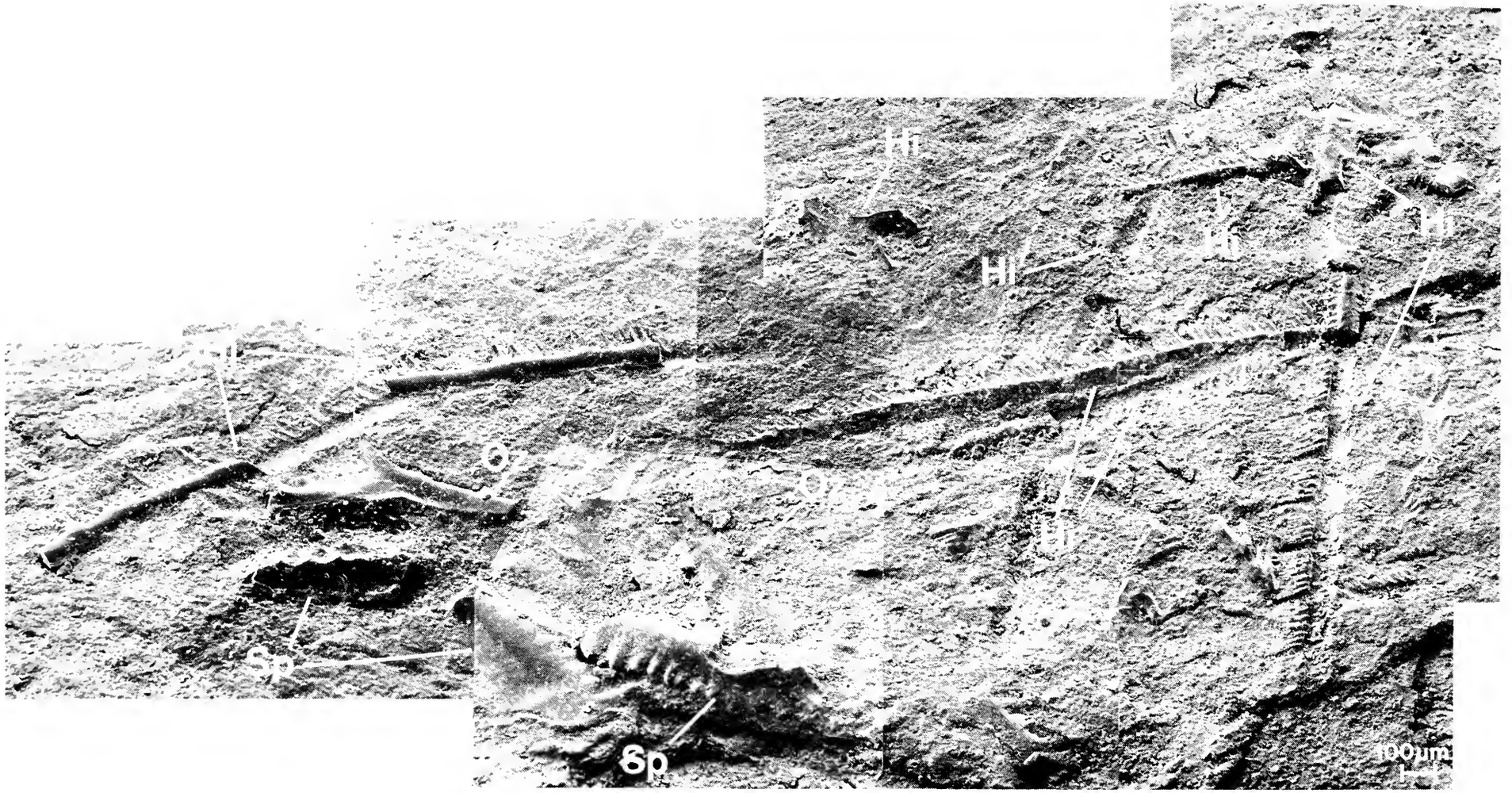


Fig. 2 *Neognathodus* cf. *dilatus* (Stauffer and Plummer), natural assemblage 2, NE¼, NW¼, sec. 11, T50N R31W, Jackson Co., Missouri, Anna Member (Middle Pennsylvanian). University of Missouri, UMC1078-7.

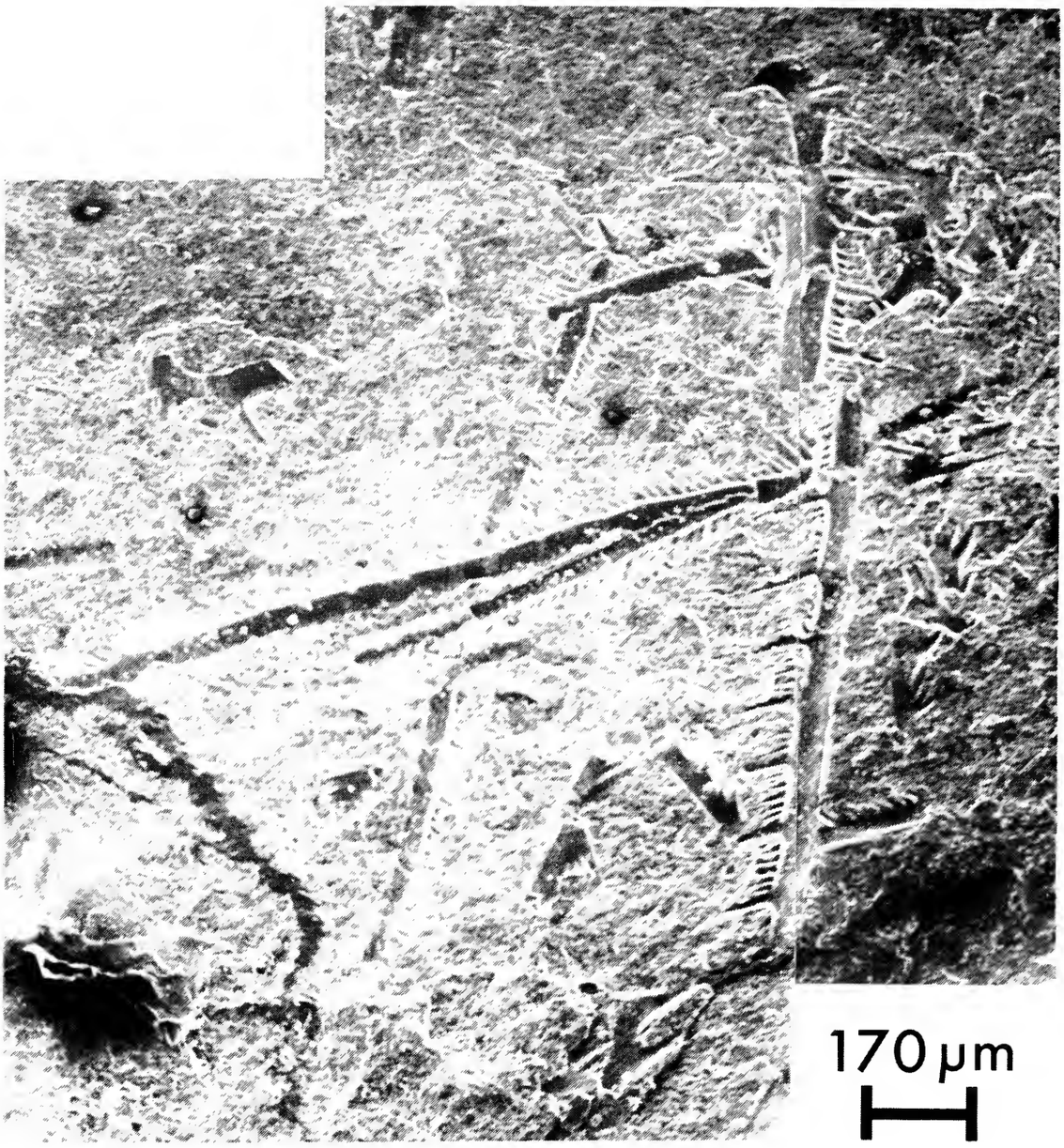
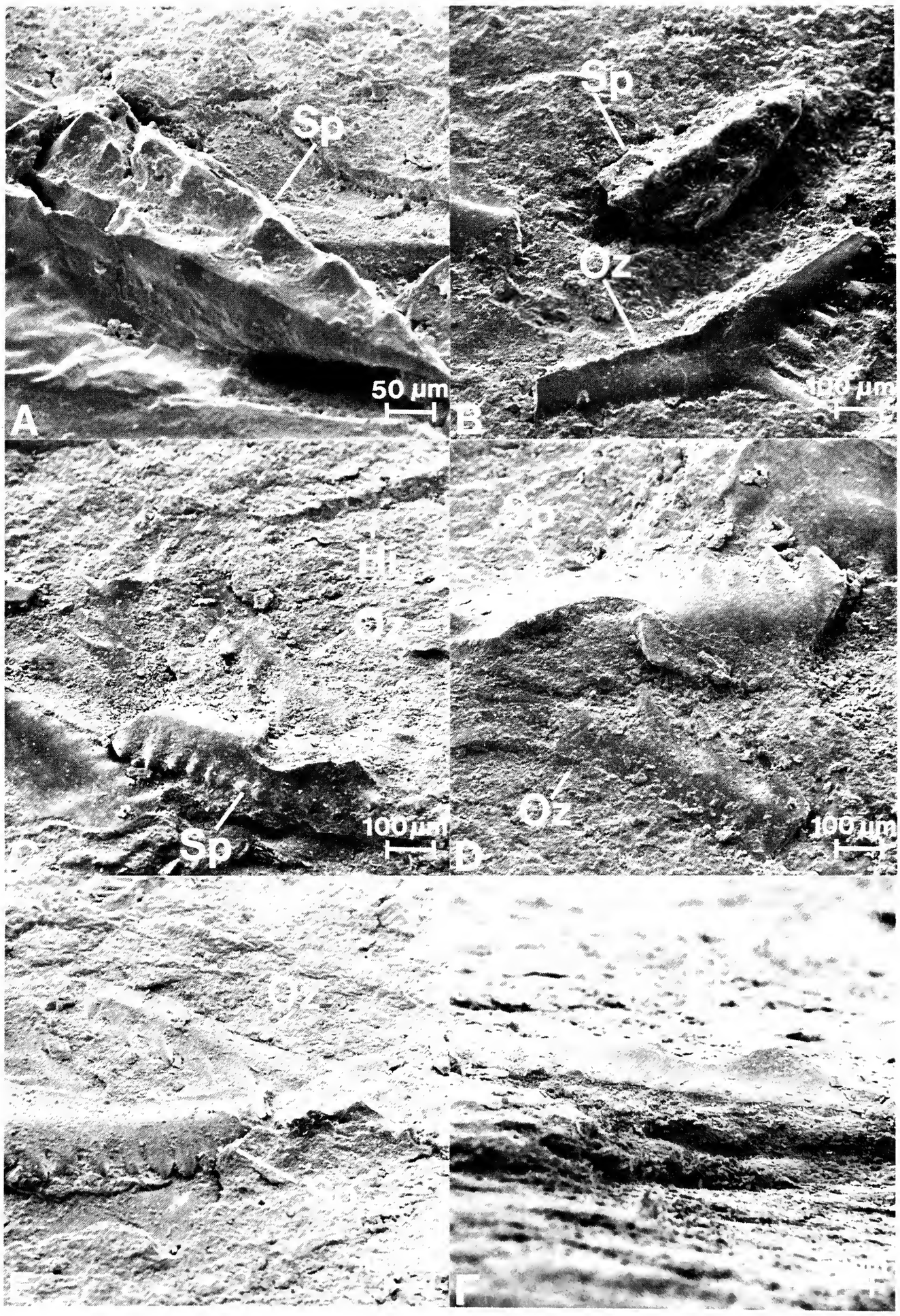


Fig. 3 *Neognathodus* cf. *dilatus* (Stauffer and Plummer), natural assemblage 2, NE¼, NW¼, sec. 11, T50N R31W, Jackson Co., Missouri, Anna Member (Middle Pennsylvanian). University of Missouri, UMC1078-7. Hi elements of natural assemblage 2.

Fig. 4 A-F. *Neognathodus* cf. *dilatus* (Stauffer and Plummer), natural assemblage 2, NE¼, NW¼, sec. 11, T50N R31W, Jackson Co., Missouri, Anna Member (Middle Pennsylvanian). University of Missouri, UMC1078-7.

A. Oral view of well-exposed Sp element.
B. Oral view of same Sp element shown in Fig. 4A; part of platform broken away.
C. Lateral view of partially buried Sp element after preparation.
D. Lateral view of same Sp element shown in Fig. 4C after preparation.
E. Lateral view of same Sp element shown in Figs. 4C, D before preparation.
F. Oral view of same Sp element shown in Figs. 4C, D, E after preparation.


Sp
50 µm
A
Sp
Oz
100 µm
B
Sp
100 µm
C
Oz
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D
E
F

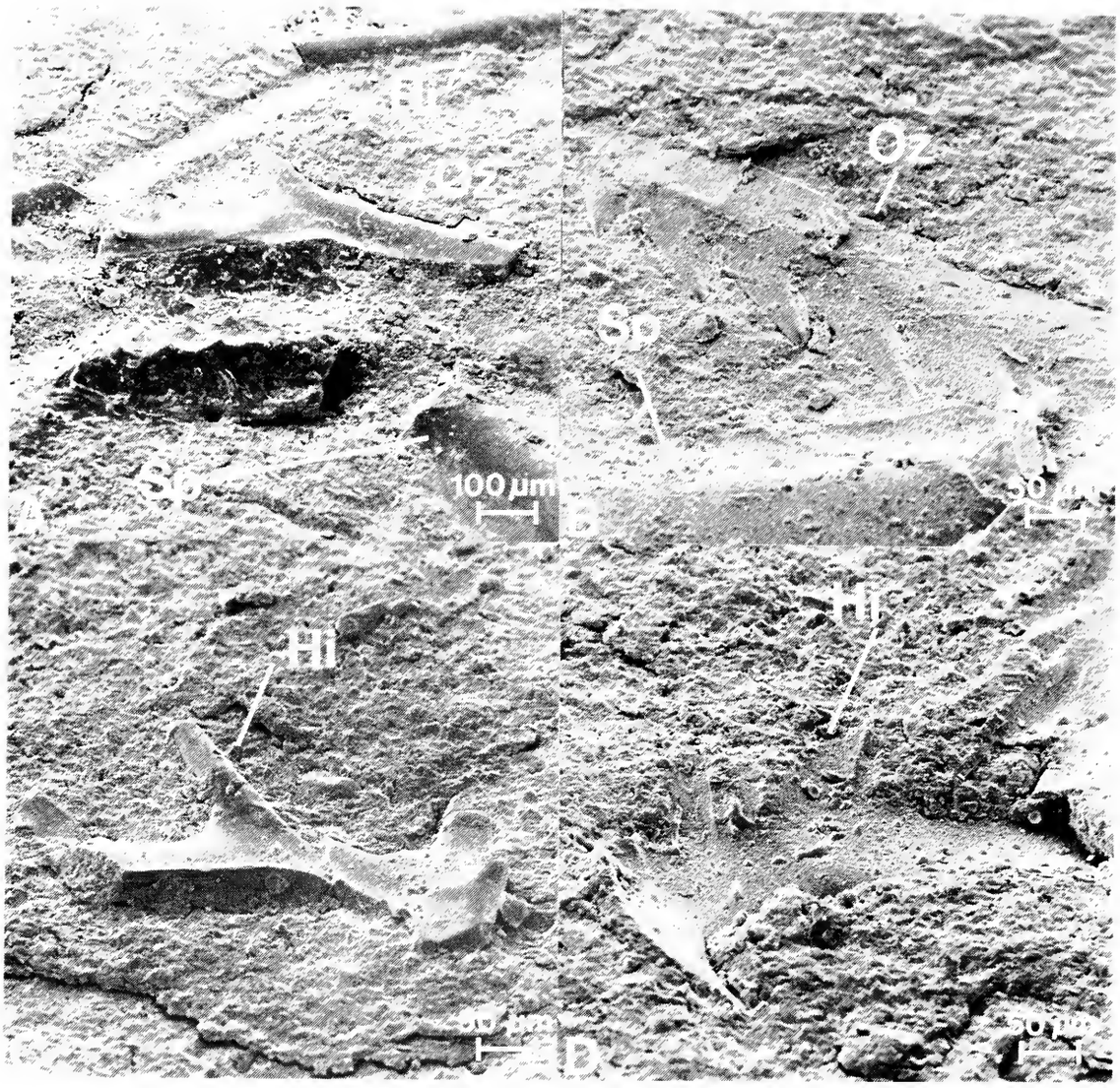

Fig. 5 A-D. *Neognathodus* cf. *dilatus* (Stauffer and Plummer), natural assemblage 2, NE¼, NW¼, sec. 11, T50N R31W, Jackson Co., Missouri, Anna Member (Middle Pennsylvanian). University of Missouri, UMC1078-7.

A. Lateral view of complete Oz element.

B. Lateral view of anterior bar of partially covered Oz element.

C. Lateral–aboral view of anterior portion of Hi element.

D. Lateral view of mould of anterior portion of Hi element.

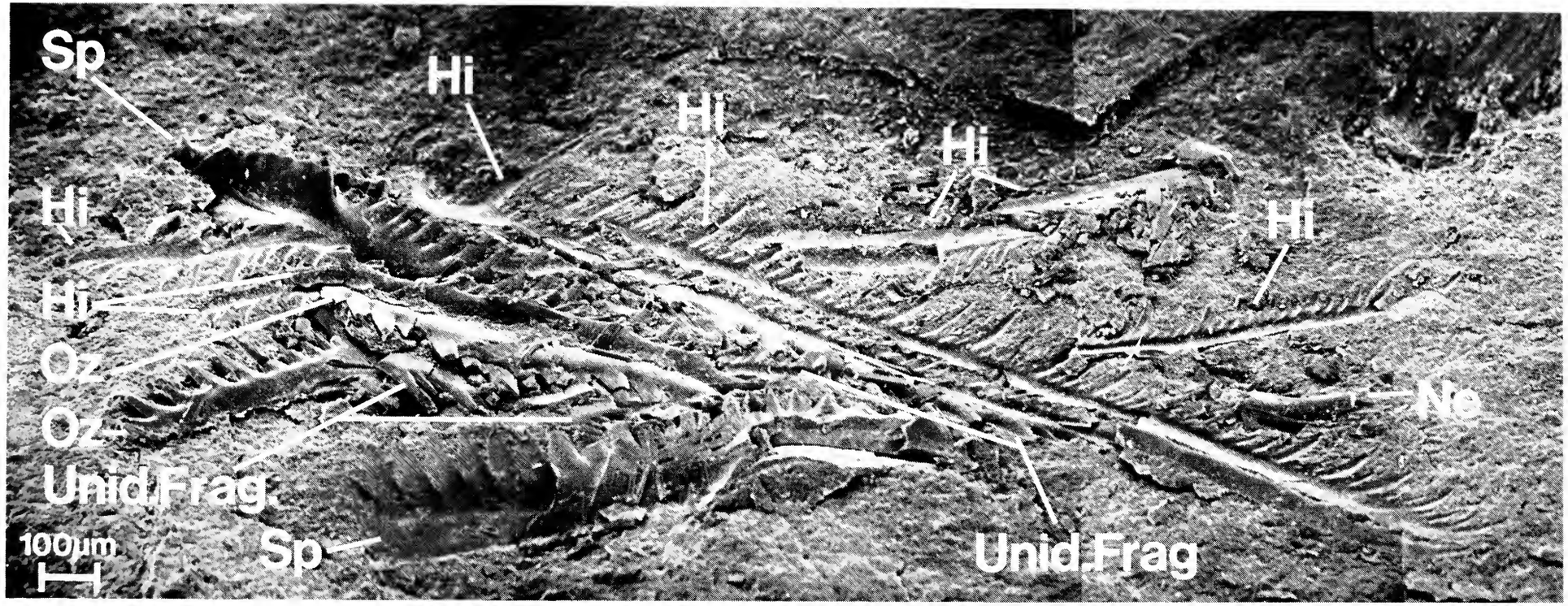

Fig. 6 *Neognathodus* sp., natural assemblage 3, SW¼, sec. 20, T22N R14E, Tulsa Co., Oklahoma, Seminole Formation (Upper Pennsylvanian). Field Museum, W.M. 44604.

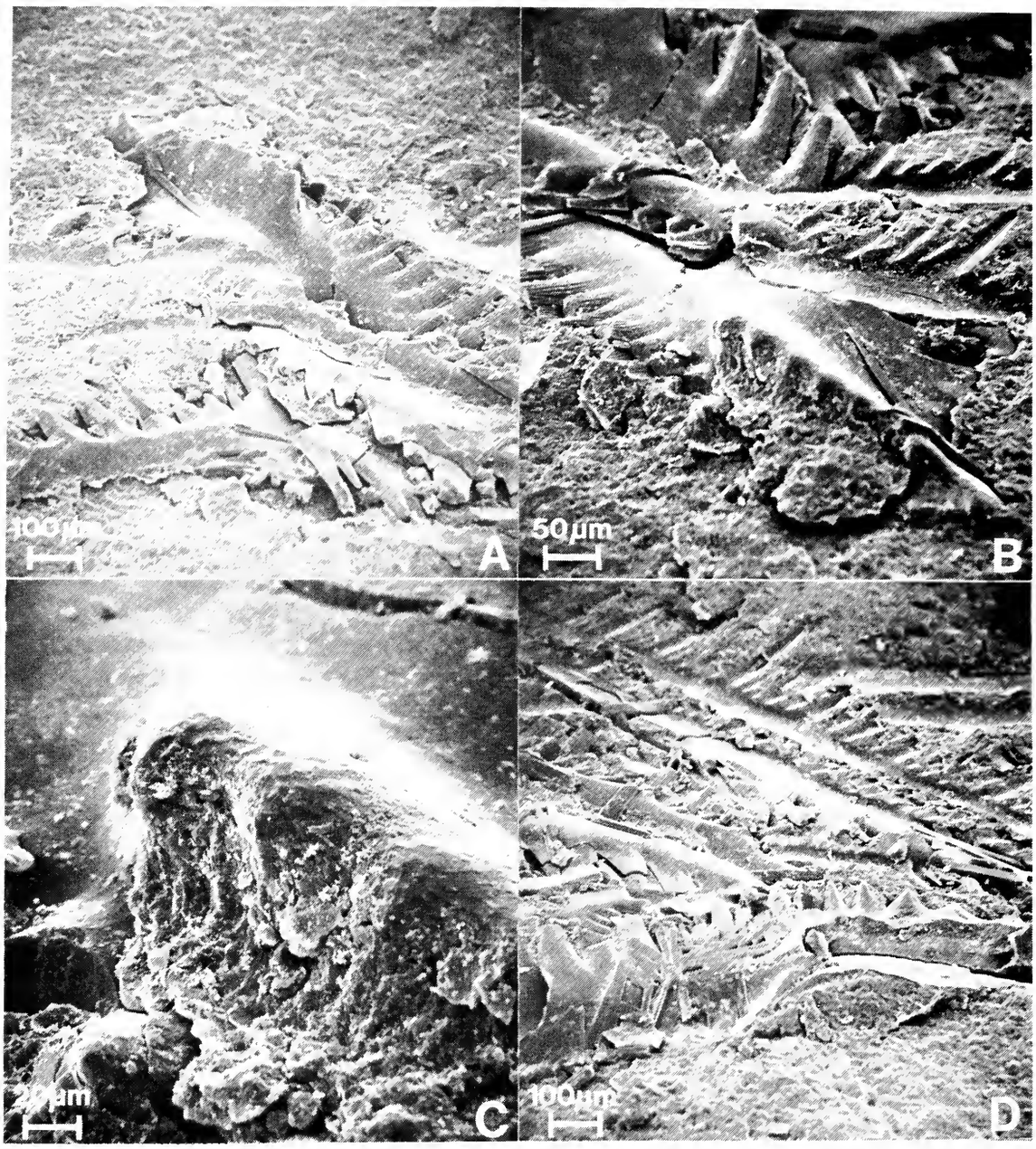

Fig. 7 A-D. *Neognathodus* sp., natural assemblage 3, SW¼, sec. 20, T22N R14E, Tulsa Co., Oklahoma, Seminole Formation (Upper Pennsylvanian). Field Museum, W.M. 44604. Detail of natural assemblage shown in Fig. 6.

A. Sp element overlying Hi elements, unidentified fragment sandwiched between opposite facing Oz elements.

B. Oral posterior view of Sp element shown in Fig. 7A.

C. Detail of nodose parapet of Sp element shown in Figs. 7A, B.

D. Sp element in foreground, Oz element and Hi element in background. Laths on anterior blade are gypsum crystals.

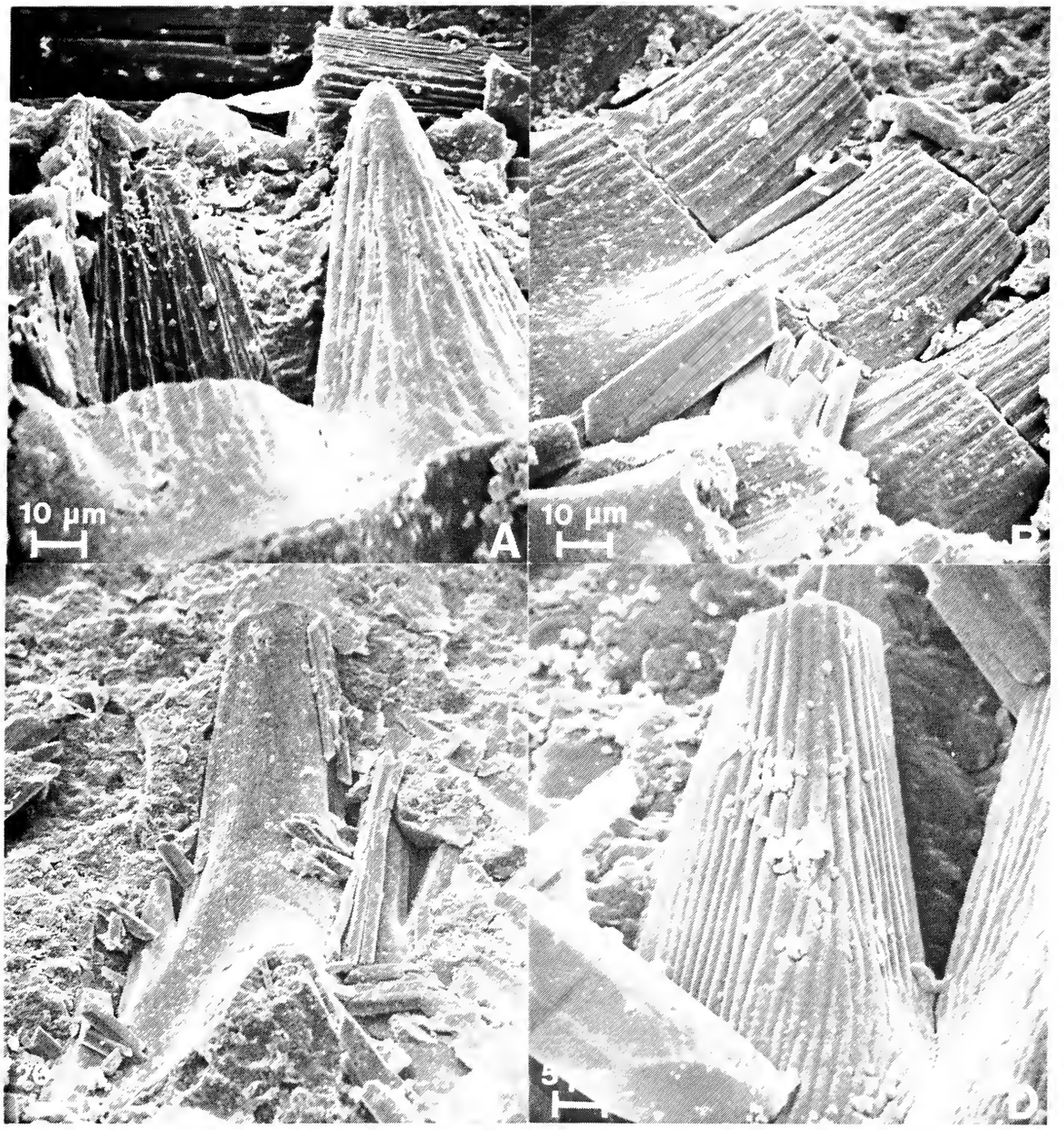

Fig. 8 A-D. *Neognathodus* sp., natural assemblage 3, SW¼, sec. 20, T22N R14E, Tulsa Co., Oklahoma, Seminole Formation (Upper Pennsylvanian). Field Museum, W.M. 44604. Detail of natural assemblage shown in Fig. 6.

A. Detail of denticle striation and corresponding mould of two denticles on carina of Sp element in Fig. 7D.

B. Detail of denticle striation of Sp element in Fig. 7A. Gypsum crystals in foreground.

C. Ne element. Inner lateral view; gypsum crystals covering element.

D. Detail of denticle striation on Ne element. Gypsum crystals at left.

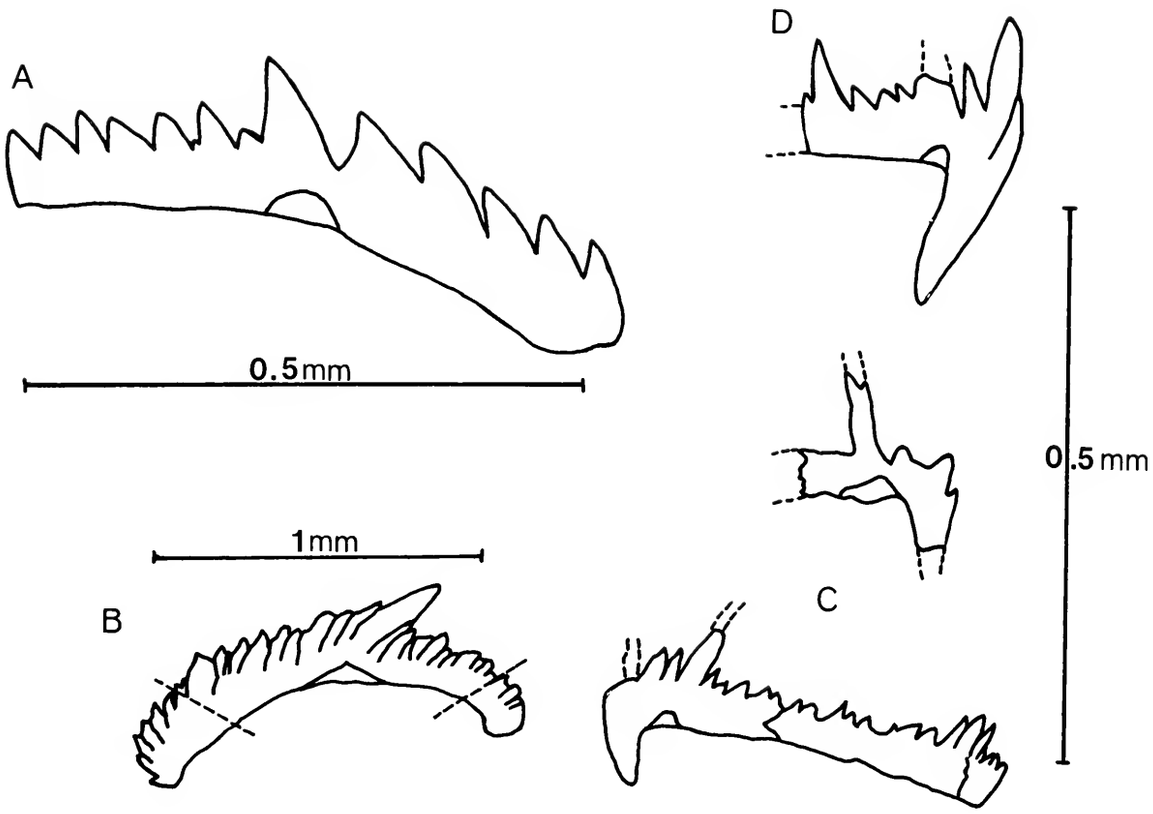

Fig. 9 A-D. *Camera lucida* drawings of Oz and Hi elements from the apparatuses of approximately contemporaneous species of *Neognathodus* and *Idiognathodus*.

A. *Neognathodus* cf. *dilatus* (Stauffer and Plummer), composite drawing of two Oz elements, natural assemblage 2, NE¼, NW¼, sec. 11, T50N R31W, Jackson Co., Missouri, Anna Member (Middle Pennsylvanian). University of Missouri, UMC1078-7.

B. *Idiognathodus* sp., composite drawing of three Oz elements, SW¼, SW¼, SW¼, sec. 4, T11N R9E, Chillicothe Township, Illinois. Sample Brereton 22B of Merrill (1975). ROM35057.

C. *Neognathodus* cf. *dilatus* (Stauffer and Plummer), Hi elements, natural assemblage 2, NE¼, NW¼, sec. 11, T50N R31W, Jackson Co., Missouri, Anna Member (Middle Pennsylvanian). University of Missouri, UMC1078-7.

D. *Idiognathodus* sp., Hi element, NE¼, SW¼, SW¼, sec. 26, T12N R3E, Copley Township, Knox Co., Illinois. Sample Brereton 12A of Merrill (1975). ROM35058.

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